TOTAL MAXIMUM DAILY LOAD (TMDL)

For

FECAL COLIFORM

IN

SHADES CREEK WATERSHED
(Including Shades Creek, Mud Creek, Mill Creek, and Cooley Creek)

EPA
United States Environmental Protection Agency

Region 4 serving the southeast

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

On the 1998 and 2000 303(d) list, the Alabama Department of Management (ADEM) identified Shades Creek as not supporting its designated use of Fish and Wildlife for pathogens, siltation, turbidity, habitat, and dissolved oxygen. In 1998, Shades Creek was delisted for dissolved oxygen. On the 303(d) list, ADEM identified collection system failure and urban runoff/storm sewers as the probable sources of impairment of Shades Creek (ADEM, 1998). Three tributaries of Shades Creek, Cooley, Mill, and Mud Creeks also were identified on the 303(d) list as partially supporting the Fish and Wildlife designated use. ADEM identified pastures/grazing as the probable source of impairment in Mud, Mill, and Cooley Creeks.

EPA first proposed Total Maximum Daily Loads (TMDLs) for the Shades Creek Watershed in November 2001. The TMDLs addressed impairment due to both siltation and pathogens. EPA received substantial comments on the TMDLs after the public notice. Based on these comments, EPA decided to separate the TMDLs into individual reports and modify the approach used to calculate the TMDLs. The TMDLs developed in this report address impairment due only to pathogens. Impairment due to siltation will be addressed in a separate TMDL.

Watershed Description

The Shades Creek watershed is located in north-central Alabama in parts of Jefferson, Bibb, Tuscaloosa, and Shelby counties. The Shades Creek watershed lies within the Cahaba River basin, hydrologic unit 03150202. Shades Creek is a tributary to the Cahaba River. Mud Creek discharges to Shades Creek near the confluence of Cahaba River. The Mud Creek watershed includes Mill Creek, which discharges directly into Mud Creek, and Cooley Creek, a tributary to Mill Creek.

Land use in the headwaters of the Shades Creek watershed is urban as the stream originates south of Birmingham. Land uses in the mid to lower parts of the Shades Creek watershed, as well as in the Mud Creek watershed are predominately forest and agriculture.

TMDL Approach

This TMDL addresses both wet weather and continuous sources of fecal coliform bacteria. Wet weather sources are discharged to a receiving waterbody as a result of storm events. For the purpose of this TMDL, wet weather sources are broadly defined into two categories based on regulatory authority of the National Pollutant Discharge Elimination System (NPDES) program. Wet weather sources regulated by the NPDES program include industrial activities and discharges from Municipal Separate Storm Sewer Systems (MS4s). In general, industrial activities are not a source of fecal coliform. The NPDES regulated sources are provided a Waste Load Allocation (WLA). Wet weather sources not regulated by the NPDES program include runoff from land uses. Non-regulated sources of fecal coliform are provided a Load Allocation (LA). Continuous sources of fecal coliform, as the name implies, continuously discharge fecal coliform to a receiving waterbody regardless of weather conditions. Continuous sources have NPDES permits and are provided a WLA.

Currently, there are two NPDES facilities in the Shades Creek watershed that require monitoring of fecal coliform bacteria. Both facilities discharge into Mud Creek. The TMDL provides these facilities their current NPDES permit limits as individual WLAs. The WLAs for these facilities are appropriate, as a review of discharge monitoring reports did not indicate effluent concentrations in violation of permit requirements. Jefferson County and the City of Birmingham have one MS4 permit that covers a portion of the Shades Creek watershed. The MS4 permit does not have fecal coliform limits; however, the permit requires monitoring for fecal coliform. In the TMDL, the MS4 is provided an individual WLA.

For a TMDL to be established for the various sources of fecal coliform to the receiving waters, a numeric "target" protective of the designated uses of the waterbodies must be identified as the basis for the TMDL. State regulation provides numeric water quality criteria for pathogens. In Alabama, fecal coliform is used as the indicator for pathogens. The Fish and Wildlife use classification includes other usage of the waterbody, such as incidental water contact and recreation during June through September. Numerical criteria associated with the incidental water contact and recreation use classification was established as the target for the TMDLs as this has the most stringent criteria of the given designated use classifications. All other designated uses for the waterbodies will be protected by attainment of the TMDL developed for the incidental water contact and recreation use.

Pathogen TMDLs presented in this report are calculated based on a mass balance approach. In the original TMDLs, EPA developed a numerical model of the Shades Creek watershed, but limited data were available to quantify sources and calibrate the model. Comments received from the public questioned the modeling approach given the limited data. In the mass balance approach presented here, water quality and stream flow data collected in 1996 in the Mud Creek watershed were used to estimate fecal coliform loadings carried in Mud, Mill, and Cooley Creeks. These two field studies are the only source of water quality data for these streams. Fecal coliform loads in Shades Creek were based on monitoring data collected by ADEM and the Storm Water Management Authority, Inc. (SWMA).

The fecal coliform TMDLs for waterbodies listed as impaired due to pathogens in the Shades Creek watershed are summarized in the table below. WLAs for NPDES facilities are based on current permit limits for fecal coliform and facility design flows. WLAs for MS4 areas are estimated as the load remaining after the total instream load was reduced for contributions from nonpoint sources. LAs for nonpoint sources are based on literature values.

Stream	**WLA (counts/day)**		**LA (counts/day)**	**MOS (counts/day)**	**TMDL (counts/day)**	**Percent Reduction**
	Wet weather[3]	**Continuous Sources**				
Shades Creek (Upper watershed)[1]	1.58×10^{12}	0	9.33×10^{10}	1.86×10^{11}	1.86×10^{12}	28%
Shades Creek (Lower watershed)[2]	1.63×10^{12}	4.98×10^{10}	3.24×10^{12}	5.42×10^{11}	5.42×10^{12}	23%
Mud Creek (At Shades Cr)	0	4.98×10^{10}	5.00×10^{10}	1.11×10^{10}	1.11×10^{11}	43%
Mill Creek (At Mud Cr)	0	0	5.02×10^{10}	5.57×10^{9}	5.57×10^{10}	87%
Cooley Creek (At Mill Cr)	0	0	1.73×10^{10}	1.92×10^{9}	1.92×10^{10}	85%

1. Upper Shades Creek watershed is defined as the drainage area above monitoring station SH1A.
2. Lower Shades Creek watershed is defined as the drainage area between the upper watershed and the confluence with Cahaba River. Loads into the lower watershed are from all upstream areas.
3. Wet weather source is from the MS4.

Recommendations

The WLAs provided to the NPDES facilities will be implemented through the State's NPDES program. The WLAs provided to the NPDES-regulated MS4 areas should be incorporated into the NPDES permits as Best Management Practices (BMPs). LAs for nonpoint sources should be achieved through the voluntary application of BMPs.

As the science and available data from wet weather discharges continues to grow, more advanced approaches to fecal coliform TMDLs may be developed. New approaches will be applied, as appropriate, through the adapted management process to enhance the effectiveness of TMDLs for providing a sound basis for water quality management decisions.

The effectiveness of the TMDL will be assessed within the context of the State's rotating watershed management approach. Watershed monitoring and assessment activities will provide information by which the effectiveness of fecal coliform loading reduction measures can be evaluated. Monitoring data and source identification actions should enable implementation of particular types of BMPs to be directed to specific areas in the watershed. The TMDLs will be revaluated during subsequent watershed cycles and revised as necessary to assure attainment of water quality standards.

1.0 Introduction

1.1 Background

Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to identify waterbodies which are not meeting their designated use. A Total Maximum Daily Load (TMDL) is required for pollutants causing the use impairment. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between the pollution sources and instream water quality conditions. This allows states to establish water quality based controls to reduce pollution and restore and maintain the quality of their water resources (USEPA 1991).

TMDLs are expressed as Waste Load Allocations (WLAs) for point source discharges from facilities regulated by the National Pollutant Discharge Elimination System (NPDES) permit program and Load Allocations (LAs) for all nonpoint sources. The TMDL must also provide an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limits and water quality. A TMDL is denoted by the equation:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

TMDLs developed for the Shades Creek watershed are expressed in terms of organism counts per day and as a percent reduction of instream concentration required to achieve the designated use. The TMDLs represent the maximum load the stream can assimilate to achieve water quality standards.

1.2 Watershed Description

Shades Creek is located in the upper portion of the Cahaba River Basin. The drainage area of the watershed, as measured from the headwaters to the confluence of the Cahaba River, is approximately 138 square miles. From the headwaters in northeastern Jefferson County, Alabama, Shades Creek flows through urban areas south of Birmingham to its confluence with the Cahaba River near the Shelby and Bibb County lines (see Figure 1). Fifty-five miles of Shades Creek, from its source to the Cahaba River, is non-supporting of the fish and wildlife designated use.

Mud Creek is a tributary of Shades Creek and has a drainage area of about 28 square miles. Within the Mud Creek watershed is Cooley Creek and Mill Creek. Cooley Creek discharges to Mill Creek, and Mill Creek discharges into Mud Creek (see Figure 2). Cooley, Mill, and Mud Creeks are listed as partially supporting the fish and wildlife designated use classification. The impaired portion of Mud Creek is 3.7 miles and extends from its source to Tannehill Iron Works. The drainage area of Cooley Creek, measured from the headwaters to the confluence of Mill Creek, is about 5 square miles. The impaired portion of Cooley Creek is 3.8 miles and extends from its source to the confluence with Mill Creek. The drainage area of Mill Creek is about 15 square miles.

The impaired portion of Mill Creek is 5.4 miles and extends from its source to Mud Creek. Figures 1 and 2 show the geographic location, monitoring stations, and impaired stream reaches of the Shades Creek and Mud Creek watersheds, respectively.

The Shades Creek watershed lies within the Valley and Ridge Province, and consists of parallel ridges and valleys underlain by highly folded and faulted rocks of Cambrian to Pennsylvanian age. The upper portions of the watershed lie within the ecoregion designated as Southern Limestone/Dolomite Valleys, while the lower portion lies within the Southern Shale Valleys ecoregion.

Land use distribution for the impaired reaches is presented in Table 1 and shown spatially in Figure 3. The basis of the land use distribution is the Multi-Resolution Land Characteristic (MRLC) database of 1993. The upper portion of the Shades Creek watershed flows through the urban areas of Birmingham. The southern part of the Shades Creek watershed, including the area encompassing the Mud Creek watershed, is predominately forest and agriculture. Urban sprawl is occurring throughout the Shades Creek watershed, including the Mud Creek watershed. Urban sprawl is not reflected in the MRLC land use distribution as dense tree cover in urban areas is often characterized as forested areas.

Table 1. Land Use Distribution in the Shades Creek Watershed

Land Use	Cooley Creek At TSP-6 (Acres)	(%)	Mill Creek At Mud Cr (Acres)	(%)	Mud Cr At Shades Cr (Acres)	(%)	Shades Cr At SH1A (Acres)	(%)	Shades Cr At TSP12 (Acres)	(%)
Deciduous Forest	788	26.9	3083	32.8	6270	35.1	9032	31.3	30122	34.0
Emergent Herbaceous Wetlands	0	0	4	0	9	0.1	6	0.0	75	0.1
Evergreen Forest	189	6.5	715	7.6	2012	11.2	3181	11.0	10999	12.4
High Intensity Commercial/Indust./ Transportation	22	0.8	50	0.5	79	0.4	2010	7.0	2390	2.7
High Intensity Residential	1	0	3	0	5	0	1044	3.6	1085	1.2
Low Intensity Residential	3	0.1	26	0.3	42	0.2	3946	13.7	4461	5.0
Mixed Forest	641	21.9	2373	25.3	4738	26.5	7171	24.8	24468	27.6
Open Water	0.9	19	117	1.3	235	1.3	72	0.2	467	0.5
Other Grasses (Urban/recreational; parks, lawns)	33	1.1	37	0.4	63	0.4	854	3.0	1137	1.3
Pasture/Hay	1013	34.6	2322	24.7	2797	15.6	477	1.7	7176	8.1
Quarries/Strip Mines/Gravel Pits	0	0	0	0	40	0.2	270	0.9	476	0.5
Row Crops	207	7.1	501	5.4	897	5	714	2.5	2963	3.3
Transitional	0	0	2	0	30	0.2	26	0.1	359	0.4
Woody Wetlands	0	0	156	1.7	670	3.7	59	0.2	2366	2.7
Total	2926	100	9389	100	17885	100	28862	100	88544	100

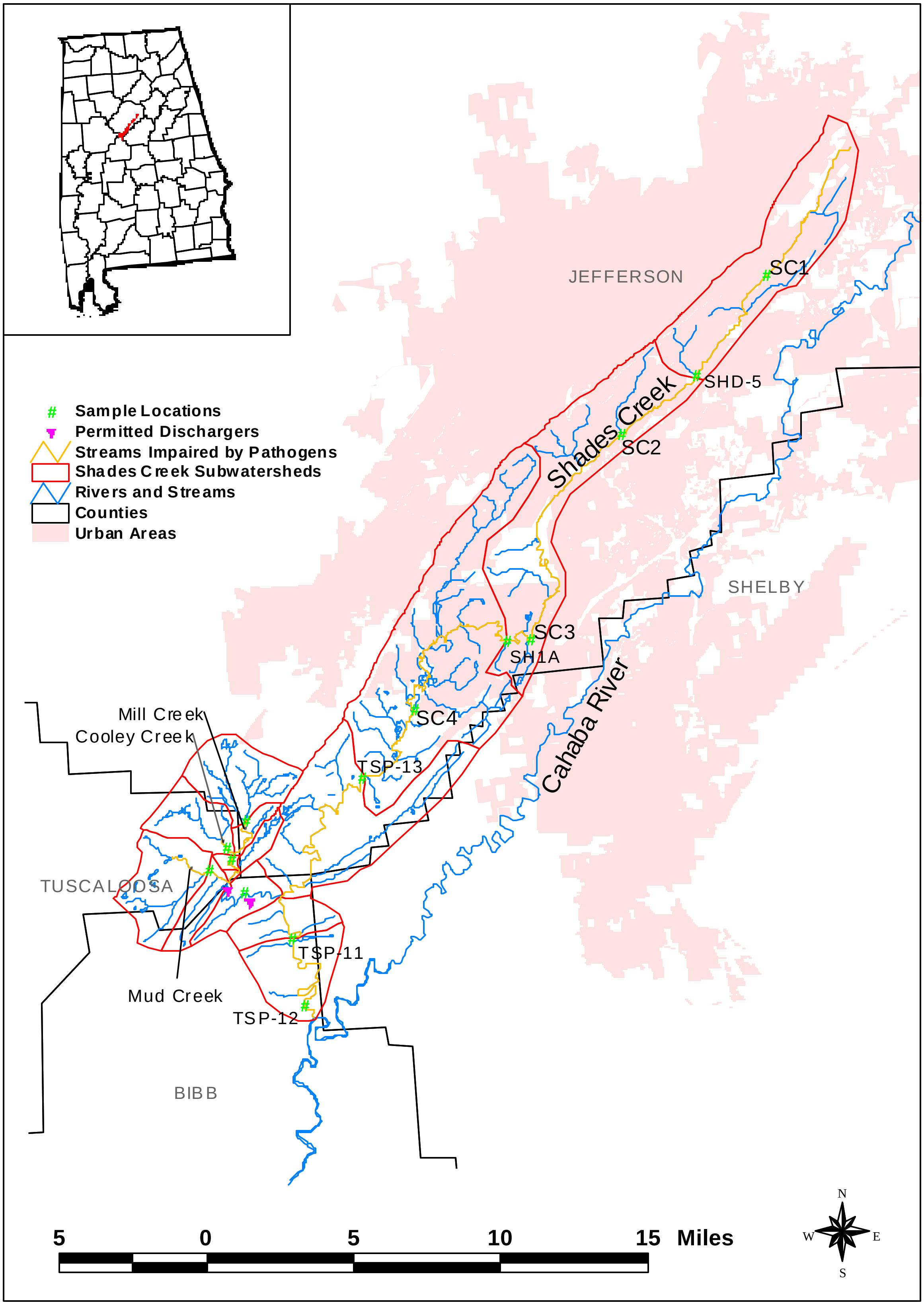

Figure 1. Shades Creek Watershed

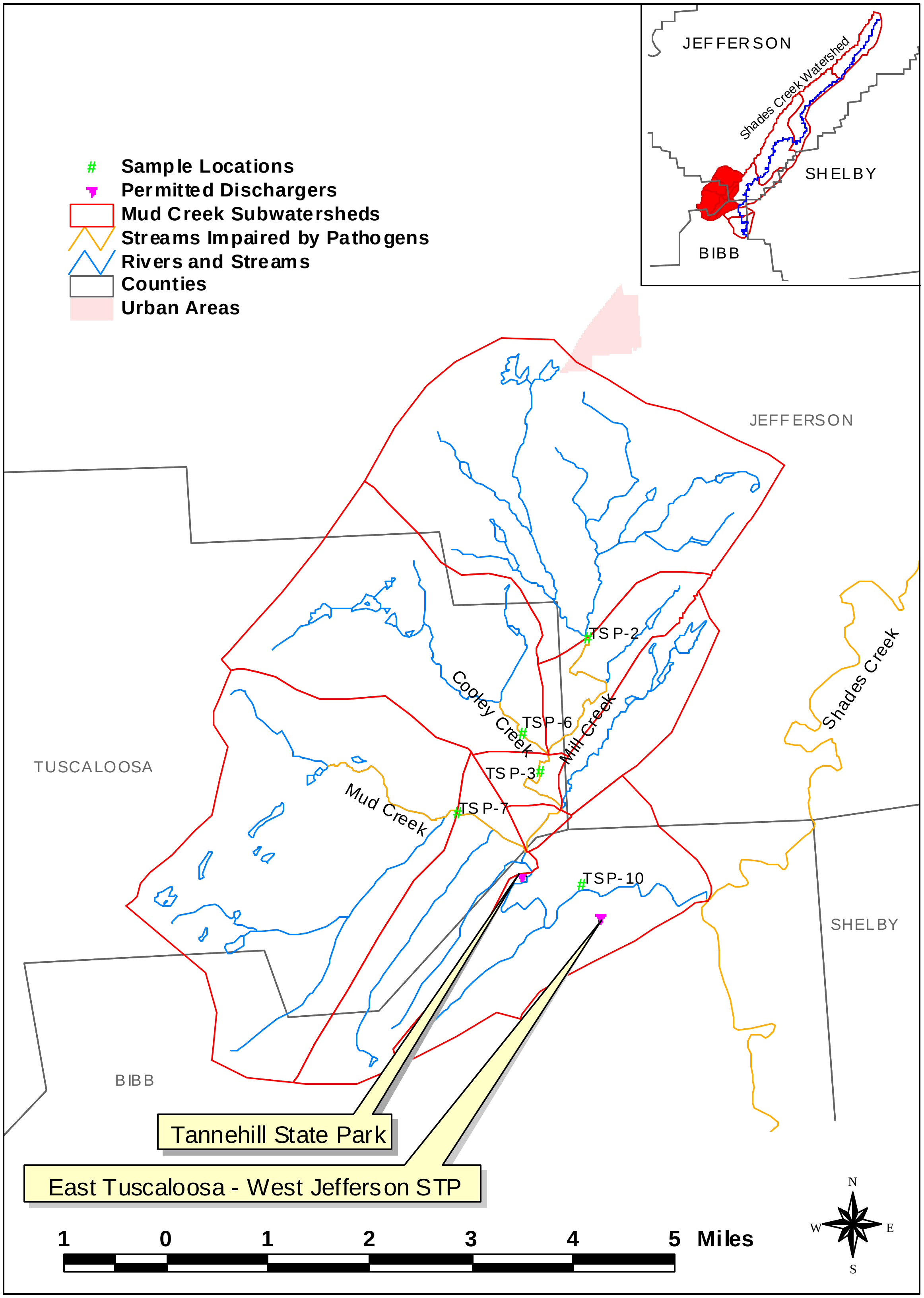

Figure 2. Mud Creek Watershed

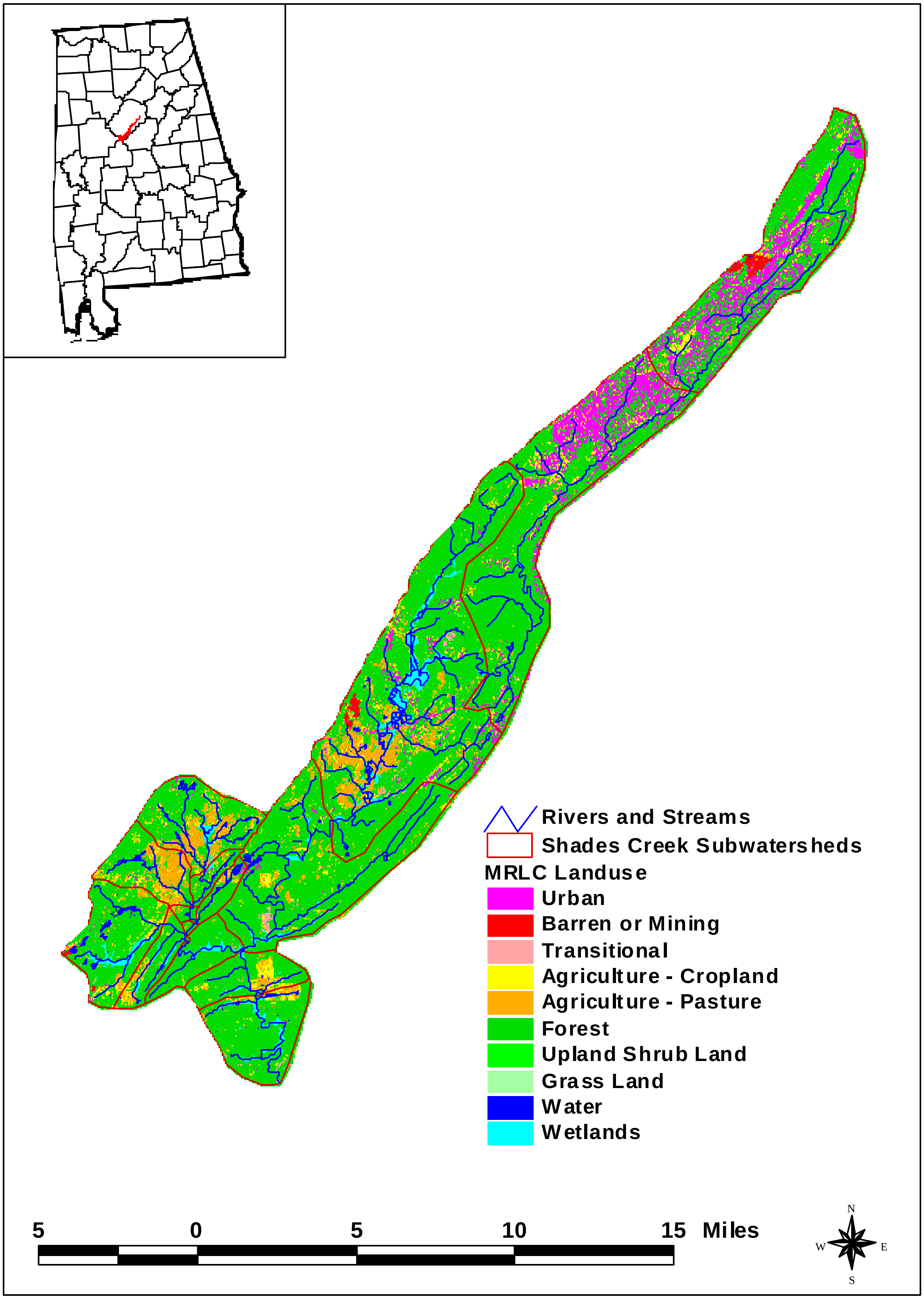

Figure 3. Landuse in the Shades Creek Watershed

1.3 Water Quality Standard

The use classification for the listed streams in the Shades Creek watershed is Fish and Wildlife and is described in ADEM Admin. Code R. 335-6-10-.09(5)(a), (b), (c), and (d).

(a). Best usage of waters:
Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food processing purposes.

(b). Conditions related to best usage:
The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c). Other usage of waters:
It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d). Conditions related to other usage:
The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

1.4 TMDL Indicators and Numeric Targets

In Alabama, fecal coliform is used as the indicator for pathogens. ADEM currently does not have water quality criteria for E. coli contamination. Criteria for acceptable bacteria levels for the Fish and Wildlife use classification are presented in ADEM Admin. Code R. 335-6-10-.09(5)(e)7.(i) and (ii).

i. Bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000 colonies/100mL; nor exceed a maximum of 2,000 colonies/100mL in any sample. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours.

ii. For incidental water contact and recreation during June through September, the bacterial quality of water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100 colonies/100mL in coastal waters and 200 colonies/100mL in other waters. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours. When the

> geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes, are not acceptable of swimming or other whole body water-contact sports.

The water quality criteria for the incidental water contact and recreation use is the most protective criteria for fecal coliform, and is the basis for the TMDLs. The TMDLs are expressed in terms of a maximum daily load in units of counts per day and a percent reduction necessary to achieve an instream geometric mean concentration of 200 counts/100mL and an instantaneous concentration of 2,000 counts/100mL. The TMDLs are calculated using the water quality criteria and the flow estimated at the time of sampling. TMDL calculations are included in Appendix B.

When sufficient data were collected to evaluate the geometric mean, as is the case for Mill, Cooley and Mud Creeks, a criterion of 200 counts/100mL is the target concentration for the TMDLs as this results in a smaller load than using the instantaneous criterion. For the main stem of Shades Creek, data were available to evaluate the compliance with the instantaneous criterion only. This criterion of 2,000 counts/100mL was used to develop the TMDL for the main stem of Shades Creek.

The TMDLs for Cooley, Mill, and Mud Creeks are calculated at the downstream monitoring station, and apply to the entire impaired segment. Shades Creek is divided into an upper and lower watershed based on the land use characteristics. The upper watershed, defined by the area draining into station SH1A (see Figure 1) is predominately urban and impacted by MS4 outfalls. . The lower Shades Creek watershed is defined as the area between station SH1A and the confluence with the Cahaba River. The TMDL for the upper Shades Creek watershed is calculated based on monitoring data collected at SWMA monitoring station SC3 (see Figure 1). The TMDL for the lower Shades Creek watershed is calculated at monitoring station TSP-11, as this is the monitoring station with the most water quality data. This TMDL includes loads from the upstream subwatersheds and applies to the end of the listed segment at the Cahaba River.

2.0 Water Quality Assessment

ADEM places waterbodies on the 303(d) list based on EPA's guidance for the development of §305(b) Report (EPA, 1997). EPA guidelines for use support determinations for conventional water quality parameters are as follows.

- Fully Supporting – For any one pollutant or stressor the criteria is exceeded in ≤ 10 percent of the measurements.
- Partially Supporting – For any one pollutant or stressor the criteria is exceeded in 11 to 25 percent of the measurements.
- Not Supporting - For any one pollutant or stressor the criteria is exceeded in >25 percent of the measurements.

For conventional parameters, such as bacteria, with geometric mean and instantaneous maximum criteria, both must be met for a stream to be considered fully supporting the designated use. If one of two criteria is met, the stream is listed as partially supporting. For conventional parameters, EPA's §305(b) guidance does not provide a time period on which to base support status. The support status for Shades Creek and its tributaries is based on all data collected on the sampling stations.

Two intensive data collection efforts were conducted in the Mud Creek watershed in June and September 1996. There has been no additional monitoring in the Mud Creek watershed. ADEM collects ambient water quality data on Shades Creek at station SH1A three times a year. In addition, ADEM conducted an intensive field study in Shades Creek in 1997. Data collected at the ambient water quality stations, as well as data collected in 1996 and 1997, were used to place Shades, Mud, Mill, and Cooley Creeks on the 303(d) list. Select monitoring stations on Shades, Mud, Mill, and Cooley Creeks are shown on Figures 1 and 2. Fecal coliform data collected at select locations in the watershed are shown in Table 2. Where sufficient data are available to calculate the geometric mean, this value is also provided in Table 2. During the field studies, stream flows were measured on select days. Instantaneous flows are also included in Table 2.

Jefferson County and the City of Birmingham have an NPDES Municipal Separate Storm Sewer System (MS4) permit to discharge storm water to Shades Creek. A Storm Water Management Authority (SWMA) was formed in 1997 to implement the requirements of the permit. The SWMA monitors fecal coliform, as well as E. coli, at four stations (SC1, SC2, SC3, and SC4) in Shades Creek (see Figure 1) during both wet weather and dry conditions. Monitoring station SC4 was established in 2002 to characterize water quality from homogeneous land use within the MS4 area. ADEM's water quality standard for bacteria is based on fecal coliform and not E. coli. Only fecal coliform data collected by ADEM and SWMA were used to estimate bacteria loadings.

As shown in Table 2, Cooley, Mill, and Mud Creeks had 10 percent of the samples exceeding the instantaneous criterion; however, all streams were in violation of the geometric mean criterion. Since one of the two criteria for bacteria were in violation of the water quality standard, the streams were listed as partially supporting the designated use. Data collected in July 1997 in Shades Creek is the basis for the non-supporting status. During this data collection effort, 17 of 46, or 37 percent, of the samples analyzed were in violation of the instantaneous criterion. The complete list of samples collected during this survey is included in Appendix A.

Monitoring data collected by SWMA indicate violations of the instantaneous criterion typically occur during wet weather conditions (see Appendix A). This would indicate stormwater runoff as the primary source of contamination. Figure 4 shows the variation in fecal coliform concentrations at the SWMA sites during wet weather conditions. From this plot the highest violations typically occur in the upper portion of the watershed, which is characterized by older housing developments.

Table 2 . Monitoring data at Select Stations in the Shades Creek Watershed

Station	**Sample Date**	**Fecal Coliform Concentration (counts/100 mL)**	**Flow (cfs)**	**Station**	**Sample Date**	**Fecal Coliform Concentration (counts/100 mL)**	**Flow (cfs)**
SH1A Shades Cr	10/14/98	37		SHD5 Shades Cr	6/4/97	>6000	4.8
	10/13/99	200			7/9/97	16400/19400	3.13
	8/5/99	120			7/10/97	8400	2.29
	8/9/00	128			8/19/97	3920	3.1
	6/2/99	550			9/16/97	0	1
	6/7/00	92					
TSP13 Shades Cr	6/4/97	490	>50	TSP11 Shades Cr	6/19/96	108/116	37.15
	7/9/97	230	46.92		6/20/96	30	36.63
	7/10/97	540	50.86		6/26/96	25	
	8/19/97	2260	83.1		7/2/96	96	
	9/16/97	0	9.2		7/8/96	2600	
					Geometric mean	**116**	
TSP12 Shades Cr	6/19/96	700		TSP11 Shades Cr	9/10/96	N/A	26.48
	6/20/96	30			9/11/96	338	
	9/10/96	N/A	33.68		9/12/96	2300	
	9/11/96	258			9/18/96	220/140	
	9/12/96	180			9/24/96	340	
					9/30/96	920/820	
					Geometric mean	**116**	
TSP-2 Mill Cr	6/19/96	1280	2.48	TSP-6 Cooley Cr	6/19/96	1580	0.66
	6/20/96	380			6/20/96	590	
	6/26/96	200			6/26/96	350	
	7/2/96	140			7/2/96	188	
	7/8/96	42000			7/8/96	>60000	
	Geometric mean	**894**			**Geometric mean**	**1298**	
TSP-2 Mill Cr	9/10/96	N/A	2.27	TSP-6 Cooley Cr	9/11/96	290	1.31
	9/11/96	0			9/12/96	540	
	9/12/96	260			9/18/96	204	
	9/18/96	192			9/24/96	640	
	9/24/96	187			9/30/96	208	
	9/30/96	96					
					Geometric mean	**335**	

Station	Sample Date	Fecal Coliform Concentration (counts/100 mL)	Flow (cfs)	Station	Sample Date	Fecal Coliform Concentration (counts/100 mL)	Flow (cfs)
TSP-3 Mill Cr	6/19/96	1060		TSP-7 Mud Creek	6/19/96	3640	3.93
	6/20/96	940			6/20/96	620/560	
	6/26/96	480/430			6/26/96	370	
	7/2/96	630			7/2/96	330	
	7/8/96	>60000			7/8/96	960	
	Geometric mean	**1531**			**Geometric mean**	**759**	
TSP-3 Mill Cr	9/11/96	460		TSP-7 Mud Creek	9/11/96	236	3.85
	9/12/96	310			9/12/96	250	
	9/18/96	740			9/18/96	204	
	9/24/96	310/300			9/24/96	174	
	9/30/96	240			9/30/96	140	
	Geometric mean	**378**			**Geometric mean**	**197**	
TSP-10 Mud Creek	6/19/96	620	13.35	TSP-10 Mud Creek	9/11/96	145	10.91
	6/20/96	96	13.10		9/12/96	96	
	6/26/96	108			9/18/96	1160	
	7/2/96	98/84			9/24/96	64	
	7/8/96	8700			9/30/96	57	
	Geometric mean	**348**			**Geometric mean**	**143**	

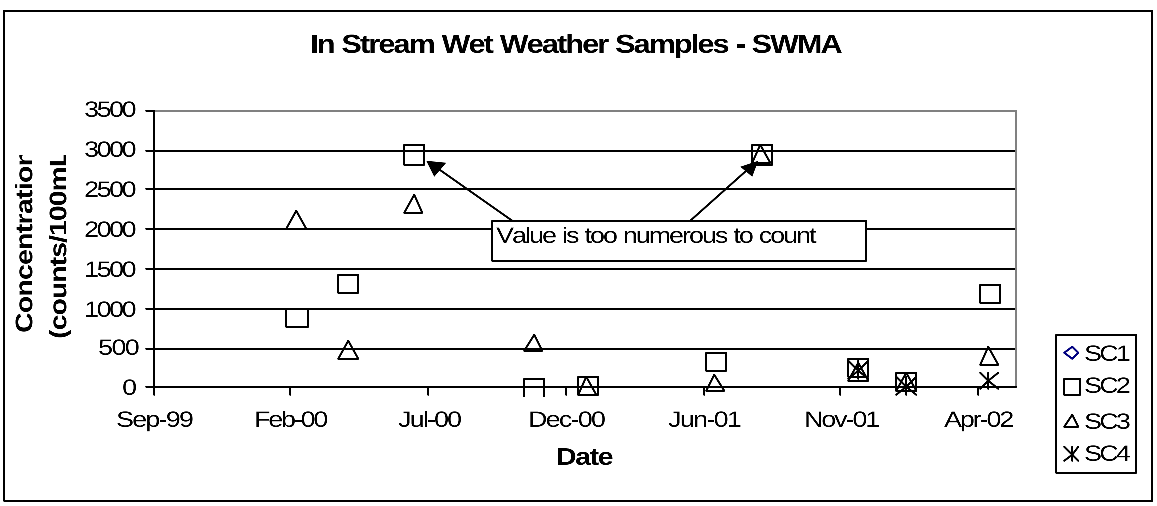

Figure 4. Fecal Coliform Concentrations at SWMA Sampling Locations

3.0 Source Assessment

An important part of the TMDL analysis is the identification of sources of fecal coliform in the watershed and an estimate of the amount of pollutant loading contributed by each of these sources. Under the Clean Water Act, sources are broadly classified as either point or nonpoint sources. This section of the TMDL describes the point and nonpoint sources of fecal coliform in the watershed.

3.1 Point Source Assessment

Under 40 CFR 122.2, a point source is defined as any discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The NPDES program regulates point source discharges. Point sources can be described by two broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities; and 2) NPDES regulated industrial activities and MS4 discharges. A TMDL must provide WLAs for all NPDES regulated point sources. For the purposes of the Shades Creek TMDL, the WLA is separated into two components: 1) continuous discharge facilities; and 2) wet weather discharges.

3.1.1 Continuous Discharge NPDES Facilities

Continuous discharge facilities, as the name implies, discharge treated wastewater continuously regardless of weather conditions. NPDES facilities that continuously discharge effluent containing fecal coliform bacteria include sewer treatment plants (STP) and wastewater treatment plants (WWTP). Two continuous discharge facilities are located within the Shades Creek watershed. Tannehill State Park (AL 0056359) and East Tuscaloosa-West Jefferson STP (AL 0068420) discharge treated effluent into Mud Creek (see Figure 2). Both facilities have seasonal permit limits for effluent concentration of fecal coliform equivalent to water quality criteria. From June through September, permit limits are 200 counts/100mL, and during all other times, permit limits are 2000 counts/100mL. Effluent discharges at or below the water quality criterion do not cause or contribute to water quality impairment. Future continuous discharge facilities located on 303(d) listed waters should discharge wastewater at concentrations that do not exceed the water quality criterion.

The existing fecal coliform load for the continuous discharge facilities were estimated based on the design flow of the facilities and summer permit limits for fecal coliform bacteria of 200 counts/100 mL (based on a geometric mean concentration). The design flow of the Tannehill facility is 0.08 million gallons per day (mgd). The design flow of the East Tuscaloosa-West Jefferson WWTP is 0.8 mgd. Estimated loads from the facilities are: 4.53×10^{9} counts/day from the Tannehill State Park STP; and 4.53×10^{10} counts/day from the East Tuscaloosa- West Jefferson WWTP. These are conservatively high estimates of the loads from the NPDES facilities as the effluent from the plants is typically at concentrations less than 200 counts/100mL. Conservative estimates of the existing loads from the continuous discharge facilities contribute to a margin of safety in the TMDLs.

3.1.2 Wet Weather NPDES Facilities

Large and medium MS4s serving populations greater than 100,000 people are required to obtain an NDPES storm water permit. At present, Jefferson County/City of Birmingham and 22 other municipalities are included in one MS4 permit regulated by the NPDES program (ALS000001). In March 2003, EPA initiated Phase II MS4 permits for municipalities of 50,000 people. Currently, Sylvan Springs is the only Phase II municipality to join the SWMA program (personal correspondence with SWMA, 2003).

The upper Shades Creek watershed, from the headwaters to the Jefferson County line, is within the MS4 permit area (personal correspondence with SWMA, 2002). Discharges from MS4s occur in response to storm events. During rain events, fecal coliform originating from domestic pets, wildlife, and other urban sources, is transported to the stream through road drainage systems, curb and gutter systems, ditches, and storm drains. The MS4 permit requires quarterly collection of water quality samples at select locations and times. Samples are analyzed for conventional pollutants, including fecal coliform. The MS4 permit does not have fecal coliform concentration limits.

Fecal coliform loadings from the MS4 area were estimated from the total instream load at SWMA's monitoring station SC3. The existing load was calculated based on the instream fecal coliform concentration measured at station SC3 and the flow in the stream. The USGS operates a continuous flow gage (02423630 Shades Creek near Greenwood, AL) near monitoring station SC3. The flow at station SC3 was estimated based on flow at the USGS gage and the ratio of the drainage area at station SC3 to the drainage area at the USGS gage. The load from the upper Shades Creek MS4 outfalls is estimated from the total fecal coliform load in the stream less contributions from nonpoint sources (i.e., leaking septic systems and leaking sewers). The existing fecal coliform load from MS4 outfalls is estimated at about 2.34×10^{12} counts/day (see Appendix B for calculations).

3.2 Nonpoint Source Assessment

Nonpoint sources of fecal coliform bacteria are diffuse sources that cannot be identified as entering the waterbody at a single location. These sources generally involve land activities that contribute fecal coliform bacteria to streams during rainfall runoff events. Nonpoint sources are all sources not regulated by the NPDES program. The TMDL must provide a load allocation (LA) for these sources. Typical nonpoint sources of fecal coliform bacteria include:

- Runoff from agricultural lands
- Septic systems, leaking sewers, and urban runoff
- Wildlife and animals with access to streams

The Watershed Characterization System (WCS), a geographic information system (GIS) interface, was used to display, analyze and compile spatial and attribute data (EPA, 2001). Available data sources included land use category, point source discharges, soil type and characteristics, population data (human and livestock), digital elevation data, stream characteristics, precipitation and flow data. The Alabama Soil and Water Conservation Committee (ASWCC, 1998) compiled a database of land use activities and practices throughout the state. The database was compiled from questionnaires completed by the local county extension services in the various watersheds. Queries of the WCS and ASWCC databases provide the foundation of the watershed characterization for the Shades Creek watershed. Fecal coliform production rates from the nonpoint sources were estimated using the data from these queries and literature values for fecal coliform concentrations from the various sources.

3.2.1 Runoff From Agricultural Lands

High fecal coliform concentrations in surface water runoff may result from improper application of animal waste on pastures and croplands and grazing livestock. Animal populations are recorded by county and reported by the National Agricultural Statistic Service (USDA, 1997). Data from the NASS web site (www.nass.usda.gov/census) were compared with information provided by the county extension services to verify the types of animals in the Shades Creek watershed. Animal populations for counties in the Shades Creek watershed are shown in Table 3. The portion of the watershed in Shelby County is small and considered insignificant in terms of loading from agriculture. As a result, livestock distribution in Shelby County is excluded from Table 3.

Table 3. Livestock Distribution by County (NASS, 1997)

Livestock	**Number of Animals per County(NASS, 1997) and Number in Shades Creek Watershed (ASWCC, 1998)**					
	Bibb		Jefferson		Tuscaloosa	
	Animals In County	No. in Watershed	Animals in County	No. in watershed	Animals in County	No. in watershed
Cattle	8242	0	6816	1500	13547	652
Beef Cow	NA	NA	3795	NA	7554	NA
Milk Cow	NA	NA	27	NA	558	NA
Hogs	13	0	704	200	48	0
Sheep						
Poultry					16720250	0

In the Shades Creek watershed, cattle operations dominate the livestock population. The population estimates shown in Table 3 represent total animals in the watershed from several farms. Based on the ASWCC database, Concentrated Animal Feeding Operations (CAFOs) are not operating in the Shades Creek watershed. Poultry operations are predominate in Tuscaloosa County; however, none of the farms were reported in the ASWCC database for the Shades watershed. Based on the land use distribution in the watershed, cattle operations are likely located in the southern portion of the watershed (see Figure 3).

Cattle in the watershed are assumed to be grazing and not confined for long periods of time. Manure collected from confined cattle is assumed to be spread on pasture and cropland. Hogs are typically confined and the manure is generally collected in lagoons and applied to land surfaces during the growing season. If the manure collected from confined animals is not spread at agronomic rates, then a portion of the fecal coliform present in the manure could wash off to the stream during a storm event.

In the Mud Creek watershed, runoff from grazed pastureland may be the cause of impairment in Mud, Mill and Cooley Creeks (ADEM, 1998). Literature values for runoff from grazed pastureland vary from 1.2×10^2 to 1.3×10^6 counts/100mL (EPA 2001).

3.2.2 Leaking Septic Systems, Sewers, and Urban Runoff

Failing septic systems can contribute fecal coliform bacteria into the waterbody. The number of people in the watershed on septic systems is based on U.S. Census Bureau population estimates for 1997 and sewer practices for the counties in the watershed. Based on county population estimates and the number of housing units in the county, each household on septic systems was assumed to house 2.3 people.

The upper portion of the Shades Creek watershed is urban whereas the southern and southwestern part of the watershed is rural and agricultural. Using best professional judgment and local information obtained from the AWSCC, it was assumed that 20 percent of the total septic systems in the watershed would leak or fail. Literature values were used to estimate the loadings from failing septic systems in the watershed using a representative effluent flow and concentration. Horsley and Witten (1996) estimate septic systems to have an average daily discharge of 70 gallons/person-day with concentrations ranging from 10^4 to 10^7 counts/100mL. For the impaired streams, the estimated loads from leaking septic systems are shown in Table 4. Calculations of the loadings are provided in Appendix B.

The loads shown in Table 4 are assumed to discharge directly into the stream. In general, septic systems discharge through the groundwater system where a portion of the fecal coliform may be absorbed on the soil. This assumption contributes to the margin of safety for the TMDL. Die-off of fecal coliform from failing septic systems is implicitly assumed in the analysis by using the lower end of the literature values for the septic effluent concentration in the calculations.

Table 4. Estimated Loads from Leaking Septic Systems

Watershed	Population on Septic	Estimated Septic Systems[4]	Estimated Septic Loading[5] (counts/day)
Upper Shades Creek (above station SH1A)	10268	4464	5.44×10^{10}
Lower Shades Creek[1] (at confluence with Cahaba R)	23558	10243	1.25×10^{11}
Mud Creek[2]	2949	1282	1.56×10^{10}
Mill Creek[3]	2462	1070	1.30×10^{10}
Cooley Creek	285	124	1.51×10^{9}

Notes:

1. Includes contributions from all subwatersheds
2. Includes contributions from Mill and Cooley creeks subwatersheds
3. Includes contributions from Cooley Creek
4. Estimated number of septic systems in a subwatershed equals population on septic divided by 2.3 people per household.
5. Loadings based on an effluent concentration of 10^4 counts/100mL and a daily discharge of 70 gal/person/day

In urban areas serviced by a wastewater treatment facility, leaking sewer lines could contribute to water quality impairment. On the 303(d) list, ADEM identified collection system failure, urban runoff and storm sewers as sources of pathogens. The Jefferson County-Trussville WWTP services the upper portion of the Shades Creek watershed. This facility discharges to the Cahaba River and has a design flow of 4 mgd. To estimate the loadings from leaking sewer lines EPA assumes five percent of the flow to the wastewater treatment plant leaks from the system at a concentration of 10^4 counts/100mL. The estimated load from leaking sewer lines is about 7.57×10^{10} counts/day (see Appendix B for calculations).

Fecal coliform from domestic pets and illicit discharges can also contribute to water quality impairment. These sources are included in the urban runoff load. Urban sprawl is occurring in the Mud Creek watershed. Leaking sewers could contribute to impairment in this area; however, insufficient data are available to verify leaking sewers as a probable source. Literature values for fecal coliform in urban runoff range from 9.6×10^2 to 4.3×10^6 counts/100mL (EPA, 2001).

3.2.3 Wildlife and Animals with Access to Streams

Wildlife deposit waste containing fecal coliform bacteria onto the land where it can be transported during a rainfall runoff event to nearby streams. Fecal coliform contributions from wildlife were based on deer population, as estimates of other wildlife are not readily available. The white-tailed deer is the predominate species found in Alabama. Due to their secretive nature it is impossible to determine precise population densities over wide areas. Using geographic information provided by the AL Division of Wildlife and Freshwater Fisheries (www.dcnr.state.al.us/agfd/), white-tailed deer density in the Shades Creek watershed is about 16 to 30 deer per square mile.

Fecal coliform loading rates due to wildlife are assumed to contribute to the background loading in the stream. On the 303(d) list, ADEM does not identify deer as a significant source of impairment of the listed waters. Therefore, for purposes of assigning a load to background conditions, a concentration of 50 counts/100mL is assumed in this TMDL. In the literature, background loadings of fecal coliform bacteria range from 1.5×10^1 to 4.5×10^5 counts/100mL (EPA, 2001).

Wildlife and other animals in the watershed may have access to streams that pass through pastures, forests, and croplands. In the 1998 AWSCC survey, District Conservationist in Tuscaloosa County indicated that livestock commonly have access to streams, and livestock water is inadequate for proper rotation of pastures. On the 303(d) list, ADEM indicated that a possible source of impairment of Mud, Mill, and Cooley Creeks is pasture grazing.

4.0 ANALYTICAL APPROACH

Establishing the relationship between instream water quality and sources of fecal coliform is an important component of the TMDL. It provides the relative contribution of the sources, as well as a predictive examination of water quality changes resulting from varying management options to meet the water quality standard. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles and literature values to numerical modeling techniques.

4.1 Model Selection

A mass balance approach was used to calculate the TMDLs for the impaired streams. In the original TMDL proposed by EPA in October 2001, a numerical model of the Shades Creek watershed was used to calculate the TMDL. Limited water quality data and the size of the watersheds of the listed tributaries warranted a simplified approach. A mass balance approach is appropriate for small watersheds with limited water quality data. Loads can be calculated using the following conservation of mass principal:

$$\textbf{Load}\,(\text{counts/day}) = (\textbf{Concentration}, \text{counts/100mL}) \times (\textbf{Flow}, \text{cfs}) \times (\text{Conversion Factor})$$

Where the conversion factor = 2.45×10^7 to obtain units of counts/day

4.2 Model Setup

The Shades Creek watershed was delineated into 15 subwatersheds based on Reach File 3 (RF3) stream coverage, Digital Elevation Model (DEM) of the area, and location of water quality monitoring stations (see Figures 1and 2). The farthest downstream point of the delineation was the confluence with the Cahaba River. The delineated watershed was used in conjunction with the WCS to quantify potential pollutant sources.

River flow influences the instream fecal coliform concentration. The USGS operates a continuous stream flow gage on Shades Creek near Greenwood, AL (USGS 02423630). The current period of record for daily flows is from October 1997 through the present. Continuous flow gages are not located on Mud, Mill, or Cooley Creeks. Mean flows in ungaged streams were estimated by multiplying the flow at the gage by the ratio of the drainage areas at the sites. A summary of monitored flow at the USGS gage on Shades Creek and an estimate flows at the sampling stations are provided in Appendix B.

4.3 Existing Fecal Coliform Loading Rates

In the Shades Creek watershed, both point and nonpoint sources contribute to water quality impairment. In the Mill Creek and Cooley Creek watersheds, only nonpoint sources contribute to the fecal coliform loadings into the stream. For Shades Creek and Mud Creek, the total loading into the stream is from both point and nonpoint sources. The existing load of fecal coliform in the stream from nonpoint sources is the difference in the total load and the load from point sources, where applicable.

The total load of fecal coliform is calculated based on the geometric mean concentration and an estimate of the average flow in the stream. For Shades Creek, insufficient monitoring data were collected to calculate the geometric mean; therefore, the instantaneous maximum concentration was used to calculate the total load. Using the equation for conservation of mass presented in Section 4.1, the existing loads of fecal coliform bacteria in the stream are calculated in Appendix B and summarized in Table 5.

There are two NPDES facilities located on Mud Creek. These facilities, identified in Section 3, contribute to the wasteload allocation (WLA) for Mud Creek and the lower Shades Creek watershed. The Jefferson County/ City of Birmingham MS4 impacts Shades Creek above the confluence with Mud Creek and is the only contributor to the WLA for the upper Shades Creek watershed. In the downstream listed segment of Shades Creek (i.e., below confluence with Mud Creek), all three point sources contribute to the WLA component.

The existing load from point source facilities was based on the design flow and average fecal coliform concentration in the effluent. For the MS4 outfalls, the existing load is based on monitoring data and an estimate of flow in Shades Creek. Flow was calculated based on a weighted drainage area of the gage site and an estimate of the area discharging into the MS4.

Table 5. Existing Loads in Shades Creek Watershed

Watershed	Point Source (Counts/day)		Runoff [1]	Leaking Septic Systems And Sewers[2]
	Continuous Discharges	Wet Weather	(Counts/day)	(Counts/day)
Upper Shades Creek (above SH1A)	0	2.21×10^{12}	See note 3	1.30×10^{11}
Lower Shades Creek (At Cahaba River)	4.98×10^{10}	2.27×10^{12}	6.79×10^{12}	1.25×10^{11}
Mud Creek (At Shades Creek)	4.98×10^{10}	0	1.275×10^{11}	1.56×10^{10}
Mill Creek (at Mud Creek)	0	0	4.14×10^{11}	1.30×10^{10}
Cooley Creek (at Mill Creek)	0	0	1.24×10^{11}	1.51×10^{9}

NOTES:
1. Runoff includes contributions from wildlife.
2. Leaking sewers are considered significant in the Shades Creek watershed (ADEM, 1998).
3. Runoff load included in the contribution from the MS4.

5.0 Total Maximum Daily Load (TMDL)

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while achieving water quality standards. The components of the TMDL are the Wasteload Allocation (WLA), the Load Allocation (LA) and a margin of safety (MOS). The WLA is the pollutant allocation to point sources while the LA is the pollutant allocation to natural background and nonpoint sources.

5.1 Waste Load Allocation (WLA)

The WLA component is divided into two components, a continuous discharge load and a wet weather load. Contributions from the continuous discharge facilities include the treatment plants located on Mud Creek. These facilities impact the WLA for Mud Creek and the lower Shades Creek segment from Mud Creek to the Cahaba River. The wet weather load is from the MS4 outfalls. This load contributes to the WLA on both the upper and lower Shades Creek watershed. WLA calculations for both components are provided in Appendix B and summarized in Table 6.

The continuous discharge facilities (i.e., STP and WWTP facilities) have permit limits for fecal coliform. The WLA for these facilities is based on the design flow of the facility and the permit concentrations of 200 counts/100mL. This is a conservative estimate of the load as the facilities use some type of disinfection prior to discharging the effluent. DMR data submitted by the NPDES facilities on Mud Creek did not indicate discharges with violations of permit limits. Future continuous discharge facilities located on 303(d) listed waters should not discharge fecal coliform at concentrations that cause or contribute to water quality impairment.

The MS4 permit does not have numerical limits for fecal coliform. Water quality data provided by SWMA indicate instream concentrations downstream of MS4 outfalls in excess of the instantaneous criterion (see Appendix A). The WLA for the MS4 is estimated from the TMDL values less the loadings assigned to nonpoint sources. The TMDL value is based on the average flow in Shades Creek at station SC3 and the water quality target of 2000 counts/100mL.

5.2 Load Allocation (LA)

The load allocation (LA) for the listed streams in the Shades Creek watershed is calculated using the water quality criterion and an estimate of mean flow during the sampling period. The geometric mean criterion of 200 counts/100mL, rather than the instantaneous criterion of 2000 counts/100mL, is used in the load calculation for Cooley, Mill, and Mud Creeks as this results in a conservative estimate of load. For Shades Creek, the instantaneous criterion is used in the load calculation. This is due to the availability of current data, which is a better indicator of the degree of contamination, and insufficient historical data for calculating the geometric mean at all monitoring stations along Shades Creek. Calculations of the LA components for the impaired streams are provided in Appendix B and summarized in Table 6.

5.3 Margin of Safety

The margin of safety (MOS) is part of the TMDL development process. There are two basic methods for incorporating the MOS (USEPA 1991):

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations, or
- Explicitly specifying a portion of the total TMDL as the MOS; using the remainder for allocations.

The MOS is incorporated explicitly in the TMDL by assuming a 10 percent reduction of the instream target concentration. When the target concentration is the geometric mean, the MOS is 20 counts/100mL; when the instantaneous criterion is the target concentration, the MOS is 200 counts/100mL. The load assigned to the MOS is based on mean flow and the assumed MOS concentration. Calculation of the explicit MOS is provided in Appendix B and summarized in Table 6.

An implicit MOS is also incorporated into the TMDL by using conservative assumptions in calculating the TMDL components. Leaking septic systems are assumed to discharge directly into the stream. Septic systems typically discharge through the soil layer where the fecal coliform could absorb to the soil. The WLA for continuous discharge facilities is based on permit limits for fecal coliform. In general, these facilities use some type of disinfection and the concentration of fecal coliform in the effluent is less than the permit limits.

5.4 Seasonal Variation and Critical Period

In developing TMDLs for listed waterbodies, seasonality is typically addressed by assuming low flow (i.e., 7Q10) or wet weather conditions. For fecal coliform, the critical period is generally a dry period followed by a rainfall event. This allows bacteria to accumulate on the ground and results in a greater concentration available to be transported to the stream during a rainfall event. For the listed streams, the critical period was selected based on the observed data. The maximum violation of the water quality criterion typically occurs during the summer months. Based on the historical record of monthly mean stream flow at the USGS gage on Shades Creek, flow in the summer and early fall (June through October) are typically the lowest. A review of water quality data collected by SWMA during both wet and dry conditions, indicate higher concentrations are recorded during wet weather events as compared to dry conditions (see Appendix B).

The critical period is the time period that results in a conservative estimate of the TMDLs. The load the streams can assimilate during the critical period should result in loads during other time periods that are protective of water quality standards. The critical period is based on the intensive surveys conducted in the lower Shades Creek watershed and a comparison of flow and fecal coliform concentration data from the SWMA. For the TMDLs, the critical period for the listed streams occurs in June. By assuming the mean flow in June as the critical flow in calculating the allowable load, seasonality is considered, as the resultant load should allow water quality standard to be achieved during other flow conditions.

5.5 Allocation

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure.

The TMDLs for the listed segments are expressed in terms of counts/day and the required percent reduction necessary to achieve water quality standards. The TMDL represents the maximum one-day load the stream can assimilate over a 30-day period and meet the target concentration. The TMDL analysis is included in Appendix B. TMDL components are shown in Table 6.

The TMDL for Shades Creek is divided into two loads based on the land use distribution. The upper Shades Creek watershed requires a 28 percent reduction of instream fecal coliform bacteria loadings to achieve water quality standards. Best Management Practices (BMPs) must be employed to reduce loadings from MS4 outfalls, and leaking septic systems and sewers. The lower Shades Creek watershed requires a 23 percent reduction in instream loadings. Much of this reduction should occur when loadings from the upper Shades Creek watershed and Mud Creek watershed are reduced. Runoff from rural areas and repair of leaking septic systems in the lower Shades Creek watershed should also be controlled to meet water quality standards.

Reductions are not required of the NPDES facilities discharging into Mud Creek. With no point source facilities discharging fecal coliform bacteria in the Mill Creek and Cooley Creek watersheds, reductions are required from nonpoint sources. Runoff from grazed pasturelands and cattle with access to streams are the probable sources of impairment in Mud, Cooley, and Mill Creeks (ADEM, 1998). Leaking or failing septic systems could also contribute to the impairment of these streams. Incorporation of BMPs to cattle operations to reduce runoff to the stream and identification and repair of failing septic systems should improve water quality conditions. Urbanization in the Mud Creek watershed may be contributing to water quality impairment through leaking sewer lines. Lack of current monitoring data does not allow for a proper evaluation of the impact of this source. Identification and repair of leaking sewers should improve water quality conditions in Mud Creek.

Table 6. TMDL Components

Watershed	TMDL (counts/day)	WLA (counts/day)		LA[2] (counts/day)	MOS (counts/day)	Percent Reduction[3]
		Continuous Sources	Wet Weather Sources[1]			
Shades Creek (Above Station SH1A)	1.86×10^{12}	0	1.58×10^{12}	9.33×10^{10}	1.86×10^{11}	28 %
Shades Creek (At Cahaba R)	5.42×10^{12}	4.98×10^{10}	1.58×10^{12}	3.24×10^{12}	5.42×10^{11}	23 %
Mud Creek (At Shades Cr)	1.11×10^{11}	4.98×10^{10}	0	5.00×10^{10}	1.11×10^{10}	43 %
Mill Creek (At Mud Cr)	5.57×10^{10}	0	0	5.02×10^{10}	5.57×10^{9}	87 %
Cooley Creek (At Mill Cr)	1.92×10^{10}	0	0	1.73×10^{10}	1.92×10^{9}	85 %

NOTES:

1. The WLA for Shades Creek includes an estimate of the load from MS4 outfalls of about 1.58×10^{12} counts/day.
2. The LA includes contributions from wildlife (background load).
3. The percent reduction applies to the LA and Wet Weather Sources of the WLA only.

6.0 Recommendations

The next phase of the TMDL is implementation. The TMDLs for Mud Creek and the lower Shades Creek watershed (i.e., at Cahaba River) allows continuous discharge facilities regulated by the NPDES program to discharge fecal coliform at their current permit levels. The WLA for these facilities will be implemented through each facility's NPDES permit.

The WLAs provided to the NPDES regulated MS4 area will be incorporated into NPDES permits as Best Management Practices (BMPs). The State will implement the WLA for the MS4 area through appropriate permit conditions.

As the science and available data from wet weather discharges continues to grow, more advanced approaches to fecal coliform TMDLs may be developed. New approaches will be applied, as appropriate, through the adapted management process to enhance the effectiveness of TMDLs for providing a sound basis for water quality management decisions. Collection of event mean concentration data should improve estimates of loading from MS4 areas.

Reductions of fecal coliform loading from nonpoint sources should be achieved using a phased approach. Voluntary, incentive-based mechanisms should be used to assure that measurable reductions in fecal coliform loadings are achieved for the targeted waterbodies. Cooperation and active participation by the general public, agricultural, business, and environmental groups are critical to successful implementation of TMDLs.

Additional evaluation should be conducted in the Mud Creek watershed to update the use support status (i.e., non, partial, or fully supporting) in Cooley, Mill, and Mud Creek. The SWMA should be encouraged to evaluate the Shades Creek watershed downstream of station SC3 to determine the impact of MS4 outfalls in the developing areas at the Jefferson County line. If future monitoring efforts are initiated in the watershed, sufficient samples should be collected seasonally to evaluate the geometric mean criterion.

The effectiveness of the TMDL will be assessed within the context of the State's rotating watershed management approach. Watershed monitoring and assessment activities will provide information by which the effectiveness of fecal coliform loading reduction measures can be evaluated. Monitoring data and source identification actions should enable implementation of particular types of BMPs to be directed to specific areas in the watershed. The TMDLs will be revaluated during subsequent watershed cycles and revised as necessary to assure attainment of water quality standards.

REFERENCES

Alabama Department of Environmental Management (ADEM). 1998. Final 1998 303(d) List. August 26, 1998.

ADEM. 2000. Water Quality Criteria. Chapter 335-6-10. Water Division – Water Quality Program.

ASWCC. 1998. Conservation assessment worksheets completed by local Soil and Water Conservation Districts. Alabama Soil and Water Conservation Committee, Montgomery, AL.

Code of Federal Regulations. "Water Quality Planning and Management." Title 40, Part 130, 2000 ed.

Horsley & Witten, Inc. 1996. Identification and evaluation of nutrient and bacterial loadings to Maquiot Bay, New Brunswick and Freeport, Maine. Final Report.

Metcalf & Eddy. 1991. Wastewater Engineering: Treatment, Disposal, Reuse. 3rd ed. McGraw-Hill, Inc., New York.

USDA. 1997. Census of Agriculture, Volume 1, Geographic Area Series, Part 42. AC97-A-42. Department of Agriculture, National Agricultural Statistics Service.

USEPA. 1991. Guidance for Water Quality – Based Decisions: The TMDL Process. EPA-440/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA, 1997. Guidelines for Preparation of the Comprehensive State Water Quality Assessment (305(b) Reports) and Electronic Updates. Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watersheds. Office of Water. September 1997.

USEPA. 1997. New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs). August 8, 1997. Memorandum from Robert Perciasepe to Regional Administrators. U.S. Environmental Protection Agency, Washington, DC. http://www.epa.gov/owow/tmdl/policy.html.

USEPA. 2001. Protocol for Developing Pathogen TMDLs. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA 841-R-00-001.

USEPA. 2001. EPA-Region 4. Watershed Characterization System – User's Manual. U.S. Environmental Protection Agency. Region 4. Atlanta, GA.

APPENDIX A

SUPPLEMENTAL FECAL COLIFORM DATA

INSTREAM SAMPLES (Source: SWMA, 2002)

Sampling Location	Wet Conditions Date	Conc. (cnts/100mL)	Dry Conditions Date	Conc. (cnts/100mL)
SC1	9/29/99	ND	9/23/99	ND
	2/14/00	512	12/29/99	14
	4/14/00	2720	3/23/00	80
	6/29/00	2948	7/7/00	1080
	11/16/00	2040	9/21/00	2948
	1/17/01	30	1/25/01	ND
	6/15/01	2860	4/19/01	40
	8/7/01	2948	7/13/01	18
	11/28/01	111	10/3/01	676
	1/23/02	36	1/9/02	30
	4/30/02	1200	4/8/02	23
	Date	Conc.	Date	Conc.
SC2	9/29/99	ND	9/23/99	ND
	2/14/00	888	12/29/99	18
	4/14/00	1320	3/23/00	130
	6/29/00	2948	7/7/00	156
	11/16/00	ND	9/21/00	2948
	1/17/01	25	1/25/01	ND
	6/15/01	340	4/19/01	18
	8/7/01	2948	7/13/01	4
	11/28/01	263	10/3/01	183
	1/23/02	76	1/9/02	ND
	4/30/02	1200	4/8/02	20
	Date	Conc.	Date	Conc.
SC3	9/29/99	ND	9/23/99	ND
	2/14/00	2120	12/29/99	29
	4/14/00	480	3/23/00	60
	6/29/00	2320	7/7/00	40
	11/16/00	570	9/21/00	50
	1/17/01	25	1/25/01	4
	6/15/01	56	4/19/01	30
	8/7/01	2948	7/13/01	4
	11/28/01	195	10/3/01	87
	1/23/02	72	1/9/02	ND
	4/30/02	406	4/8/02	2
	Date	Conc.	Date	Conc.
SC4	11/28/01	223	10/3/01	89
	1/23/02	16	1/9/02	ND
	4/30/02	84	4/8/02	ND

Note: ND = not detected; values of 2948 are code for too numerous to count (TNTC)

In-Stream sample site locations for Storm Water Mangement Authority, Inc. Birmingham, Alabama

SITE	*NORTHING*	*EASTING*	*LAT_DMS*	*LONG_DMS*	*WATERBODY*	*LOCATION or General Area*
SC1IS	1281747.48467	2207334.05059	33 31 16	-86 42 59	Shades Creek	Elder Street, near Eastwood Mall…..Birmingham
SC2IS	1255841.77523	2178613.36333	33 27 02	-86 48 40	"	Columbiana Road, Lakeshore Drive Junction ...Greensprings
SC3IS	1220984.30742	2158841.95897	33 21 18	-86 52 36	"	Hwy 150, Galleria area…Hoover

Note: (ie) CR1IS….. First letters are water body initials. The number following designates site location; 1 is most upstream; 2 is downstream etc..
IS stands for sample type: In Stream

SHADES CREEK/LITTLE SHADES CREEK INTENSIVE SURVEY
July 8-10, 1997

Station	Date	Time	Temp-Air	Temp-H_2O	DO	SpCond	Turb	Depth	pH	Flow	Weather	Fecal Coliform
	MMDDYY	HHMM	^oC	^oC	mg/l	µmho/cm	NTUs	meters	Units	cfs		org/100 mL
Storet Code			00020	00010	00300	00095	82079	00068	00400	00060	(47501)	31613
SHD-1	7/8/97	1421	31	22.43	10.02	344	7.4	0.1	7.58		L. Shower (7)	
SHD-2	7/8/97	1405	34	28.01	12.75	322	2.7	0.1	8.27		Cloudy (4)	
SHD-3	7/8/97	1350	31	25.71	10.08	295	4.8	0.1	7.77		Cloudy (4)	
SHD-4	7/8/97	1339	32	29.4	12.22	268	3.5	0.4	8.15		Cloudy (4)	
SHD-5	7/8/97	1330	32	25.3	11.12	304	1.8	0.1	7.94	9.26	Cloudy (4)	
SHD-6	7/8/97	1323	33	25.95	11.03	284	2.7	0.2	7.79		Cloudy (4)	
SHD-7	7/8/97	1304	34	25.56	9.39	280	12.5	0.5	7.4		Cloudy (4)	
SHD-8	7/8/97	1504	30	24.91	8.35	332	1.87	0.1	7.44	2.50	P. Cloudy (3)	
SHD-9	7/8/97	1446	29	26.75	9.09	272	4.68	0.1	7.47	99.23	P. Cloudy (3)	
SHD-10	7/8/97	1430	29	29.13	9.84	260	3.76	0.2	7.99		P. Cloudy (3)	
SHD-11	7/8/97	1405	29	27.33	9.84	236	3.73	0.4	8.25		Cloudy (4)	
SHD-12	7/8/97	1342	29	24.36	8.43	266	11	0.2	7.16	4.37	Cloudy (4)	
TSP-13	7/8/97	1310	30	25.78	7.52	207	15.8	0.2	7.11	32.90	P. Cloudy (3)	
SHD-1	7/9/97	0858	28	21.45	9.4	326	6.3	0.1	7.68	0.39	L. Shower (7)	40
SHD-2	7/9/97	0828	26	22.49	12.5	262	23.3	0	7.65		Cloudy (4)	600L
SHD-3	7/9/97	0806	25	22.41	9.9	189	19.6	0.1	7.45		Cloudy (4)	600L
SHD-4	7/9/97	0752	25	22.74	9.19	175	26.2	0.4	7.32		Cloudy (4)	600L
SHD-5	7/9/97	0739	24	23.02	9.52	210	19.8	0.2	7.6	3.13	Cloudy (4)	16400/19400
SHD-6	7/9/97	0727	25	23.28	9.53	155	67.4	0.2	7.41		Cloudy (4)	240L
SHD-7	7/9/97	0702	25	23.73	9.16	127	53.9	0.4	7.27		Cloudy (4)	12000L
SHD-8	7/9/97	1018	25	22.87	7.93	313	3.42	0.1	7.33	1.14	Cloudy (4)	8200
DUP-1(SHD-8)	7/9/97	1026	25	22.85	6.56	312	3.46	0.2	7.44		Cloudy (4)	12600
SHD-9	7/9/97	0950	25	23.77	7.06	136	45.9	0.1	6.94	22.28	Cloudy (4)	---
SHD-10	7/9/97	0923	23	23.99	6.41	127	53.8	0.2	7.13		Cloudy (4)	---
SHD-11	7/9/97	0848	24	24.34	6.29	112	85.7	0.4	6.78		P. Cloudy (3)	6000L
SHD-12	7/9/97	0818	22	22.32	6.75	269	13.3	0.2	7.47	2.44	P. Cloudy (3)	260
TSP-13	7/9/97	0740	21	24.73	6.18	213	24	0.3	7.3	46.92	Clear (1)	230

Station #	Sampling Location
TSP-13	Shades Creek at Jefferson County Road 53 near Summit Farm: Samples collected from bridge on downstream side at mid-channel. Park in church parking area.
SHD-12	Little Shades Creek at Alabama Highway 150: Samples collected 100 feet upstream of bridge near new manhole on left bank. Park on dirt road upstream of bridge on right bank.
SHD-11	Shades Creek at Alabama Highway 150: Samples collected under downstream side of bridge approximately 10 feet from the right bank. Park on dirt road on downstream side of bridge on right bank.
SHD-10	Shades Creek at entrance to the Wood Waste Facility (old Shannon Landfill) next to Shannon Road: Samples collected 150 upstream of bridge at mid-channel. Enter facility through wrought iron gates and cross bridge. Park on upstream side of bridge on dirt road leading down to creek.
SHD-9	Shades Creek at Oxmoor Road: Samples collected under downstream side of bridge approximately 8 feet from the right bank. Park in Wildwood Apartments construction area on downstream side of bridge. Walk down storm drain between highway and apartments.
SHD-8	Unnamed tributary to Shades Creek near Oxmoor Road: Samples collected 20 feet downstream of Snow Drive near the Homewood Firestation # 3. Park on grass on upstream side of street next to fire station.
SHD-7	Shades Creek at Greensprings Highway: Samples collected from bridge on downstream side at mid-channel. Park in shopping center parking area on right bank on downstream side of bridge.
SHD-6	Shades Creek at dead end street 300 yards upstream of Highway 280 (first street to right on northeast side of Highway 280): Samples collected approximately 20 feet downstream of bridge. Park in parking lot on downstream side of bridge across from Easy Street. Enter creek down storm drain from parking lot.
SHD-5	Watkins Brook at Mountain Brook Parkway: Samples collected in pool under bridge. Park on east side of bridge in spaces next to Jemison Park.
SHD-4	Shades Creek at Beechwood Road on downstream end of Mountain Brook Country Club: Samples collected from bridge on downstream side at mid-channel. Park next to country club on the northeast side of the bridge.
SHD-3	Shades Creek at Old Leeds Road on upstream end of Mountain Brook Country Club: Samples not collected at this site during May.
SHD-2	Shades Creek in mobile home park on Trailer Lane in Irondale (Montclair Road at I-20, turn onto Trailer Lane 100 feet southwest of I-20 overpass): Samples collected immediately upstream of small storm water ditch on northeast edge of mobile home park.
SHD-1	Shades Creek in Norris Rail Yard: Samples collected upstream of pool at storm water outfall designated 0002 on a sign next to railroad tracks where storm water drain enters Shades Creek. This location is near the northeast end of the rail yard next to Norfolk Southern Drive. Be careful, this is a busy rail yard and you will have to cross numerous tracks.

APPENDIX B

TMDL ANALYSIS

FECAL COLIFORM LOADINGS IN THE UPPER SHADES CREEK WATERSHED

1. POTENTIAL SOURCES:

A. Leaking septic systems - impact all watersheds - see worksheet, "Septic Loads"
B. Urban Runoff - included in MS4 loadings - dominate source in Shades Creek
C. Runoff from agricultural lands - impact Mud, Mill and Cooley Creeks - loading range: 1.2E+02 to 1.3E+06 counts/100mL (EPA, 2001)
D. Wildlife - background load from deer - impact Mud, Mil and Cooley Creeks - assumed loading: 50 counts/100mL (EPA, 2001)
E. Leaking sewer lines - impact urban watershed (i.e., Shades Creek) -
assume 5% of design flow of treatment plant is leached from the system at conc of 10,000 counts/100mL (EPA, 2001)

2. EXISTING LOADINGS IN UPPER SHADES CREEK WATERSHED

(ABOVE MONITORING STATION SH1A - ADEM ambient monitoring station - AND SC3 - SWMA instream sampling location)
Probably sources include: leaking septic systems and sewer lines (LA Component) and MS4 discharge (WLA Component)

2a. Sources Contributing to the LA Component

Leaking septic systems = 5.44E+10 counts/day

Leaking sewer lines = 7.57E+10 counts/day
(Jefferson Co. Trussville WWTP - AL006842 discharges outside the watershed but is assumed to service the urban areas of Jefferson Co.
Plant has a design flow of 4 million gallons per day (mgd), assume conc. in effluent is 10,000 counts/100mL and 5% leaches from system)
LOAD = 4e+6 gal/day *10000 counts/100mL * 3.785 L/gal * 1000 mL/L * 0.05 = 7.57E+10 counts/day

Urban Runoff - included in the MS4 load
Runoff from agricultural lands and wildlife - insignificant to the Upper Shades Creek watershed

2b. Sources Contributing to the WLA Component (wet weather permitted facilities (MS4) + continuous discharge facilities)

Excluding the MS4, there are no other NPDES facilities discharging directly into the upper Shades Creek watershed

MS4 Load = Total load - septic load - leaking sewer loads

Total load during critical period (summer) - based on instream monitoring at MS4 outfall:

Station	**Date**	**Concentration** (counts/100mL)	**Flow @ gage (cfs)**	**Flow[1]** (cfs)	**Total Load[2]** (counts/day)
	9/29/99	not detected			
SC3	6/29/00	2320	66	41	2.34E+12
SC1	6/15/01	2860	58	8	5.31E+11
SC3	8/7/01	2948	348	217	1.57E+13

Notes: 1. Flow based on ratio of drainage areas (DA) and monitored flow at USGS gage on sampling date

Location	**DA (square miles)**	**DA Ratio**
SC3	45.1	0.624 (estimated based on watershed delineation)
SC1	9.46	0.131 (location of USGS gage 02423571 - partial record)
USGS gage 02423630	72.3	1

DA Ratio = DA at sampling location / DA USGS gage

LOADINGS IN THE UPPER SHADES CREEK WATERSHED (cont.)

2. Load calculated using the mass balance equation: Load = flow * concentration * conversion factor

flow = cfs

concentration = counts/100mL (note: the 100mL is accounted for in the conversion factor)

conversion factor = (7.481gal/ft^3 * 3.785 L/gal * 1000mL/L * 86400 sec/day)/100mL = 2.45E+07

3. Total Existing Load (LA + WLA), counts/day, @ SC3	August (high flow)	June (average flow - critical period)
LA = leaking septics + leaking sewers =	1.30E+11	1.30E+11
WLA = MS4 load during critical period = Total Load - LA	1.55E+13	2.21E+12
Total Exising Load (counts/day) =	**1.57E+13**	**2.34E+12**

4. Margin of Safety (MOS)

MOS = flow * concentration * conversion factor

flow = average flow during critical period = 38 cfs

concentration = 10 percent of water quality critierion = 0.1*2000 counts/100mL = 200 count/100mL

conversion factor = 2.45E+07

MOS = 36 cfs * 200 counts/100mL * 2.45E+07 = 1.86E+11 counts/day

MOS (high flow) = 217*200*2.45E+07 = 1.06E+12 counts/day

5. TMDL LOAD - UPPER SHADES CREEK WATERSHED

TMDL load based on instantaneous criterion as source of impairment is wet weather conditions

instantaneous criterion = 2000 counts/100mL

critical flow based on average monthly for June (time period of highest violation at all stations)

Average June flow (based on 16 yrs of historical data - see "Flow" worksheet) = 61 cfs

Adjusted ave. June flow at sampling station SC3 = flow @ gage * DA Ratio = 38 cfs

TMDL = flow * concentration * conversion factor

TMDL = 38 cfs * 2000 counts/100mL* 2.45E+07 = 1.86E+12 counts/day (based on average historical flows)

Alternatively, basing the TMDL on high flow (I.E., 217 cfs measured in 8/01) and instantaneous criterion:

TMDL (high flow) = 1.06E+13 counts/day **(Note: load probably too high to meet standards during ave. flow conditions)**

6. PERCENT REDUCTION FOR UPPER SHADES CREEK WATERSHED

Percent Reduction = (existing load - (TMDL load-MOS)) / existing load *100

% Redux (ave flow) = (2.34E+12 - (1.86E+12-1.86E+11)) / 2.34E+12 * 100 = 28.3%

% Redux (high flow) = (1.57E+13 - (1.06E+13-1.06E+12)) / 1.57E+13 * 100 = 39.0%

7. TMDL Components (counts/day) - based on average conditions:

WLA	LA	MOS	TMDL	% Reduction
1.58E+12	9.33E+10	1.86E+11	1.86E+12	28%

FECAL COLIFORM LOADINGS IN THE MUD CREEK WATERSHED

1. POTENTIAL SOURCES:

A. Leaking septic systems - impact all watersheds - see worksheet, "Septic Loads"
B. Urban Runoff - included in MS4 loadings - for urban areas runoff range: 9.6E+02 to 4.3E+06 counts/100mL (EPA, 2001)
C. Runoff from agricultural lands - impact Mud, Mill and Cooley Creeks - loading range: 1.2E+02 to 1.3E+06 counts/100mL (EPA, 2001)
D. Wildlife - background load from deer - impact Mud, Mil and Cooley Creeks - assumed loading: 50 counts/100mL (EPA, 2001)
E. Leaking sewer lines - not significant load in Mud Creek watershed

2. EXISTING LOADINGS IN MUD CREEK WATERSHED (calculated at downstream monitoring station on each listed segment)

Mill Creek - loads estimated at TSP-3
Cooley Creek - loads estimated at station TSP-6
Mud Creek - loads estimated at station TSP-10

Watershed	Critical Period	Concentration (cnts/100mL) (geomean)	(max)	Flow[1,2] (cfs)	Load[3, max] (counts/day)	Load[4, geomean] (counts/day)
Cooley Cr	6/19 - 7/18/96	1298	>60000	3.93	5.77E+12	1.25E+11
Mill Cr	6/19 - 7/18/96	1531	>60000	11.39	1.67E+13	4.27E+11
Mud Cr	6/19 - 7/18/96	348	8700	22.66	4.82E+12	1.93E+11

NOTES:

1. Flow based on drainage area (DA) ratio and average flow at USGS gage for sampling period - (see sheet "Flows" for measured values)

Location	DA (square miles)	DA Ratio	
Mill Cr (TSP-3)	13.24	0.183	(estimated based on watershed delineation)
Cooley Cr (TSP-6)	4.57	0.063	(estimated based on watershed delineation)
Mud Cr (TSP-10)	26.34	0.364	(estimated based on watershed delineation)
USGS gage 02423630	72.3	1.000	

DA Ratio = DA at sampling location / DA USGS gage

2. Average monthly flow for July (based on historical record - gage not opertaional in 1996) = 62.2 cfs
   example calculation of flow on Cooley Creek: flow (cfs) = flow at gage * DA Ratio = 62.2 * 0.063
   Cooley flow = 3.93 cfs

3. Load = flow (cfs) * concentration (counts/100mL) * conversion factor
   where: concentration = maximum concentration measured during 30-day period
   conversion factor = (7.481gal/ft^3 * 3.785 L/gal * 1000mL/L * 86400 sec/day)/100mL = 2.45E+07

   example calculation for Cooley Creek: Load = 3.93 cfs* 60,000 counts/100mL * 2.45E+07 = 5.77E+12 counts/day
   Note: volume of 100mL in the concentration units is accounted for in the conversion factor

4. Load based on calculated geometric mean concentration for 30-day period
   example calculation for Cooley Creek: Load = 3.93 cfs * 1298 counts/100mL * 2.45E+07 = 1.25E+11 counts/day

LOADINGS IN THE MUD CREEK WATERSHED (cont.)

3. WLA Components

Facility	NPDES #	Impacted Watershed	Design Flow (MGD)	Permit Limit (counts/100mL)	Load[1] (counts/day)
Tannehill State Park	AL0056359	Mud Creek	0.08	200	4.53E+09
East Tuscaloosa - West Jefferson WWTP	AL0068420	Mud Creek	0.8	200	4.53E+10
				Total WLA:	**4.98E+10**

NOTES: 1. Load = Q (mgd) * Conc (counts/100mL) * conversion factor

conversion factor = (7.481 gal/ft^3 *3.785 L/gal *1000 mL/L) / 100 mL = 283.15585

Example Calculation for Tannehill State Park:

Load = 0.08E+06 gal/day * 200 counts* 283.15585 = 4.53E+09 counts/day

4. TMDL Components

LA = Total Load - WLA - MOS

WLA (Mud Creek) = 4.98E+10 counts/day

WLA (Mill and Cooley Cr) = 0 counts/day

MOS = 20 counts/100mL and average flow during critical period (for geometric mean criterion)

Watershed	Ave. Flow (cfs)	MOS (counts/day)
Cooley Cr	3.93	1.92E+09
Mill Cr	11.39	5.57E+09
Mud Cr	22.66	1.11E+10

Example Calculation for Cooley Creek: MOS = 3.93 cfs * 20 counts * 2.45E+07 = 1.92E+09 counts/day

Total Load = ave flow (cfs) * concentration * conversion factor

concentration = 200 counts/100mL (geometric mean)

Example for Cooley Creek:

Load (geomean) = 3.93 cfs * 200 counts/100mL * 2.45E+07 = 1.92E+10 counts/day

Load (instantaneous) = 3.93cfs * 2000 counts/100mL * 2.45E+07 = 1.92E+11 counts/day

4a. TMDL components based on water quality criterion of 200 counts/100mL

Watershed	WLA (counts/day)	LA (counts/day)	MOS (counts/day]	TMDL (counts/day)	% Reduction
Cooley Cr	0	1.73E+10	1.92E+09	1.92E+10	85%
Mill Cr	0	5.02E+10	5.57E+09	5.57E+10	87%
Mud Cr	4.98E+10	5.00E+10	1.11E+10	1.11E+11	43%

LOADINGS IN THE MUD CREEK WATERSHED (cont.)

5. Estimate of loads from potential sources contributing to existing conditions

Sources include:

Leaking Septic Systems - see worksheet "septic loads" for specific calculations

Cattle in stream - included in the runoff from ag. Lands

Runoff from agricultural lands - assume a concentration of 1200 counts/100mL (literature values: 120 - 1.3E+06 counts/100mL (EPA, 2001)

Runoff from urban lands - assume a concentration of 1000 counts/100mL (Literature values: 9.6E+02 - 4.3E+06 counts/100mL (EPA, 2001)

Wildlife - assume a concentration of 50 counts/100mL

Watershed	Total Load (counts/day)	WLA (counts/day)	Septic Load (counts/day)	Wildlife (counts/day)	Runoff (counts/day)	runoff concentration (counts/day)
Cooley Cr	1.25E+11	0	1.51E+09	4.81E+09	1.19E+11	1232
Mill Cr	4.27E+11	0	1.30E+10	1.39E+10	4.00E+11	1430
Mud Cr	1.93E+11	4.98E+10	1.56E+10	2.77E+10	9.98E+10	180 (low because of conservative est. of WLA component)

FECAL COLIFORM LOADINGS IN THE LOWER SHADES CREEK WATERSHED

1. POTENTIAL SOURCES:

A. Leaking septic systems - impact all watersheds - see worksheet, "Septic Loads"
B. Urban Runoff - included in MS4 loadings
C. Runoff from agricultural lands -
D. Wildlife - background load from deer - impact Mud, Mil and Cooley Creeks - assumed loading: 50 counts/100mL (EPA, 2001)
E. Leaking sewer lines - loading from upper Shades Creek watershed

2. EXISTING LOADINGS IN LOWER SHADES CREEK WATERSHED (calculated at downstream monitoring station on each listed segment)

Station	Date	Concentration (cnts/100mL) (geomean)	(max)	Flow[1,2] (cfs)	Load[3, max] (counts/day)	Load[4, geomean] (counts/day)	Critical Conditions
TSP-13	8/19/87	not available	2260	64.9	3.59E+12	not available	August/summer
TSP-11	6/19 - 7/8/97	116	2600	110.7	7.04E+12	3.14E+11	June/Summer
TSP-11	9/11 - 9/30/96	529	2300	127.0	7.15E+12	1.64E+12	September/Summer

Notes:

1. Flow based on ratio of drainage areas (DA) and ave. monthly flow at USGS gage during sampling period - (see sheet "Flows" for values)

Location	DA (square miles)	DA Ratio	
TSP-13	80.4	1.112	(estimated based on watershed delineation)
TSP-11	131.2	1.815	(estimated based on watershed delineation)
USGS gage 02423630	72.3	1	

DA Ratio = DA at sampling location / DA USGS gage

Example calculation at Station TSP-13: Flow @ station = ave. monthly flow @ gage during sampling period * DA Ratio =
Flow @ TSP-13 = 58.4 * 1.112 = 64.9408 cfs

2. Ave. monthly flow based on historical record at gage: June = 61 cfs; August = 58.4 cfs; and September = 70 cfs (see "Flows" worksheet)

3. Load calculated using the mass balance equation: Load = flow * concentration * conversion factor
flow = cfs
concentration = counts/100mL (note: the 100mL is accounted for in the conversion factor)
conversion factor = (7.481gal/ft^3 * 3.785 L/gal * 1000mL/L * 86400 sec/day)/100mL = 2.45E+07

Example calculation @ Station TSP-13: Load = 64.9 cfs * 2260 counts/100mL * 2.45E+07 = 3.59E+12 counts/day

3. LOAD ATTRIBUTED TO POINT SOURCES (WLA COMPONENT)

Monitoring station TSP-11 is downstream of Mud Creek. The NPDES facilities discharging into Mud Creek also contribute loading to lower Shades Creek watershed. Station TSP-13 is upstream of the confluence with Mud Creek. The NPDES facilities do not impact water quality at Station TSP-13. The MS4 impacts water quality at both stations.

4. SUMMARY OF EXISTING LOADS IN LOWER SHADES CREEK WATERSHED - DURING CRITICAL PERIOD (JUNE)

Station	Total Load[1] (counts/day)	WLA[2] (counts/day)	MS4[3] (counts/day)	LA[4] (counts/day)	
TSP-13	3.59E+12	0	2.21E+12	1.38E+12	TSP-13 is located upstream of confluence with Mud Cr
TSP-11	7.04E+12	4.98E+10	2.21E+12	4.78E+12	TSP-11 is furthest downstream station

NOTES:
1. Total load based on maximum violation of instantaneous criterion
2. WLA = wasteload allocation from NPDES facilities with fecal coliform permit limits. WLA based on design flow of facility and permit limits of 200 counts/100mL. This is a conservative estimate of the WLA as DMRs indicate these facilities discharge at concentrations less than 200 counts/100mL.
3. MS4 load based on monitoring data at the downstream sampling location (SC3). Load based on average flow conditions.
4. LA = load allocation from nonpoint sources = Total Load - WLA - MS4

5. TMDL COMPONENTS

TMDL = WLA + LA + MOS

TMDL is based on the water quality criterion of 2000 counts/100mL and average flow conditions during critical period

MOS = Margin of Safety = 10% of water quality criterion = 0.1* 2000 counts/100mL = 200 counts/100mL

MOS = ave. flow in June @ gage * DA ratio * 200 counts/100mL * conversion factor

at Station TSP-11, MOS = 61 cfs*1.815 * 200 counts/100mL * 2.45E+07 = 5.42E+11 counts/day

NOTE: the volume of 100mL in the concentration units is accounted for in the conversion factor

Station	TMDL[1] (counts/day)	WLA[2] (counts/day)	MS4[3] (counts/day)	LA[4] (counts/day)	MOS[5] (counts/day)	% Reduction[6]
TSP-11	5.42E+12	4.98E+10	1.58E+12	3.24E+12	5.42E+11	23%

NOTES:
1. TMDL is total load the stream can assimilate, based on water quality criterion of 2000 counts/100mL (criterion violated)
2. WLA based on NPDES facilities design flow and permit concentration of 200 counts/100mL (conservative)
3. MS4 load for TMDL conditions based on load required at upstream location SC3
4. LA = Total load (I.e., TMDL) - WLA - MS4 - MOS; represents total load from nonpoint sources
5. MOS based on ave. monthly flow during critical period and 10% water quality criterion
6. Percent Reduction based on total load for existing conditions and TMDL conditions (I.e., existing load - TMDL / existing load)

LOADINGS IN UPPER SHADES CREEK WATERSHED

6. Estimate of loads from potential sources contributing to existing conditions

Sources include:
Leaking Septic Systems - see worksheet "septic loads" for specific calculations
MS4 - from upper Shades Creek watershed
Runoff from agricultural lands - assume a concentration of 1200 counts/100mL (literature values: 120 - 1.3E+06 counts/100mL (EPA, 2001)
Runoff from urban lands - assume a concentration of 1000 counts/100mL (Literature values: 9.6E+02 - 4.3E+06 counts/100mL (EPA, 2001)
Wildlife - assume a concentration of 50 counts/100mL

Watershed	Total Load (counts/day)	WLA (counts/day)	MS4 (counts/day)	Septic Load (counts/day)	Wildlife (counts/day)	Runoff (counts/day)	runoff concentration (counts/day)
Lower Shades Creek	7.04E+12	4.98E+10	2.21E+12	1.25E+11	1.35E+11	4.52E+12	1.67E+03

Loading from Leaking Septic Systems

This sheet contains information related to the contribution of failing septic systems to streams.
The direct contribution of fecal coliform from septics to a stream can be represented as a point source in the model.

The following assumptions are made for septic contributions.

Assume a failure rate for septics in the watershed: 20 %

Assume the average FC concentration reaching the stream (from septic overcharge) is: 1.00E+04 #/100 ml (Horsely & Whitten, 1996)
Assume a typical septic overcharge flow rate of: 70 gal/day/person (Horsely & Whitten, 1996)

Total # people on septics is from WCS (source data: 1990 census data, estimated for 1997)
Density people/septic based on Census report for population and # household in watershed

Subwatershed	Tot. # people on septics	Density people/septic	# failing septics	Tot. # people served	Septic flow (gal/day)	Septic flow (mL/hr)	FC rate (#/hr)	Septic flow (cfs)	FC Rate (counts/day)
Upper Shades	10268	2.3	892.9	2053.6	143752	22,670,888	2.27E+09	2.23E-01	5.44E+10
Lower Shades	23558	2.3	2048.5	4711.6	329812	52,014,101	5.20E+09	5.11E-01	1.25E+11
Mud Creek	2949	2.3	256.4	589.8	41286	6,511,146	6.51E+08	6.40E-02	1.56E+10
Mill Creek	2462	2.3	214.1	492.4	34468	5,435,891	5.44E+08	5.34E-02	1.30E+10
Cooley Creek	285	2.3	24.8	57	3990	629,256	6.29E+07	6.18E-03	1.51E+09

FLOWS WORKSHEET

MEAN MONTHLY FLOWS (CFS) - 1964 THROUGH 1999 FROM WWW.USGS.GOV, 2000-2002 CALCULATED FROM DAILY VALUES

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1964										33.4	35.9	150
1965	137	341	225	137	45.7	138	84.2	35.7	31.1			
1966										30.4	47.1	46.1
1967	71	147	74.5	36.6	104	60.9	104	307	55.6	36.8	144	475
1968	309	62.2	201	146	157	39.8	133	55.2	43.7	27	39.6	203
1969	340	208	248	232	375	80.7	42.8	33.5	40.2	34.5	41.2	115
1970	117	126	478	279	62.1	91.3	42.2	60.8	36.9	81	65.6	97.6
1971	176	552	330	113	89.1	70.2	150	49.7	63.3	32.6	34.4	189
1972	438	146	177	58.5	53.4	43.8	30.7	37	79.7	53.3	95.3	228
1973	389	143	372	295	191	68.8	90.5	62	35.3			
1974										29.2	64	281
1975	447	329	328	190	93.3	58	94.3	57.7	38.7	89.9	57.3	130
1976	260	99.5	792	156	387	119	41.9	42.1	60.3	26.1	36.4	113
1977	261	198	589	409	48	23.8	34.5	23	193	282	228	91.9
1978	259	76.8	207	55.4	269	169	35.8	26.8	21	14.2	22.6	49.8
1979	278	250	338	763	108	43	57	56	275	79.5	136	63.9
1980	265	207	800	395	207	58.9	30.3	31.3	37.7	39	52.9	31.1
1981	31.7	247	246	160	36.3	41.2	37.8	42.3	35			
1997										48.5	67.5	142
1998	422	353	243	216	48.1	39.5	40.5	74.5	21.2	9.86	55.9	108
1999	308	153	245	91.7	64.3	245	56.8	8.25	6.92			
2000	156	73	410	469	18	27	27	34	4	6	72	35
2001	151	197	411	263	46	113	48	74	251	26	57	189
2002	345	156										
Mean of monthly streamflow	258.1	203.2	353.4	235.0	126.5	80.6	62.2	58.4	70.0	51.6	71.2	144.1
					modify June flow =	61						

modify mean monthly flow for June by excluding extreme events in 1965, '78, and '99